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Sentinel lesions in osteoarticular traumatology: Signs to watch out for

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KEYWORDS
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Abstract Sentinel lesions are lesions of the bone or soft tissue, visible in standard X-rays carried out within a traumatic context, indicating bone or more severe capsular ligament lesions not visible on these X-rays. A detailed review of the peripheral joints as well as the spine is carried out with an example of each type of lesion in a standard X-ray. Confrontation with the reference examination, CT or MRI, depending on the case, is then carried out.
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As a general rule, the standard X-ray is the first examination carried out in the exploration of osteoarticular traumas. For this reason, it is often a non-radiologist, emergency doctor or surgeon who provides the first interpretation. However, certain lesions are not obvious and may be missed or underestimated. Certain signs should be specifically searched for and should draw attention to the presence of a more severe underlying lesion. We call them ''sentinel lesions''. They are lesions of the bone or soft tissue that are visible in standard X-rays, indicating more severe bone or capsular ligament lesions not directly visible. There are several types: bone avulsion or fracture, intra-articular effusion, soft tissue swelling and fatty lines blurring. Bone avulsions consist of the tear of a bone fragment at the level of the insertion of a tendon, a ligament or an articular capsule. The identification of this bone fragment on a standard X-ray then confirms, according to its location, the damage of a capsular ligament structure not visible. The intra-articular effusion is sometimes the only anomaly visible in the traumatised joint. Its presence then conditions whether or not complementary examinations are required, especially if there is a fatty level (lipohemarthrosis) indicating an articular fracture with passage of bone marrow into the joint.

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The purpose of this paper is to present, for the different peripheral joints and the spine, the different sentinel lesions that may be observed in standard X-rays. We will describe their mechanism and compare the standard X-rays with imaging (CT or MRI) according to the case.

Shoulder

The first intention radiological assessment consists of a front view, a sagittal Y-view and possibly a glenoid view, Bloom-Obata or an axillary view. The indirect signs of glenohumeral dislocation should be known. An episode of spontaneously reduced dislocation may be missed, in particular within a context or epilepsy or polytrauma. The anterior dislocation (Fig. 1) — with Malgaigne notch (Hill-Sachs lesion) at the posterior-superior-lateral side of the head of the humerus, well visible in internal rotation, and tearing of the anterior-inferior edge of the glenoid (bony Bankart) — posterior dislocations (Fig. 2) where the lesions are reversed — Mac Laughlin notch at the anterior-superior-medial side of the head and reverse Bankart lesion at the posterior side of the glenoid. An exhaustive lesion assessment will be carried out by arthro-CT or arthro-MRI.

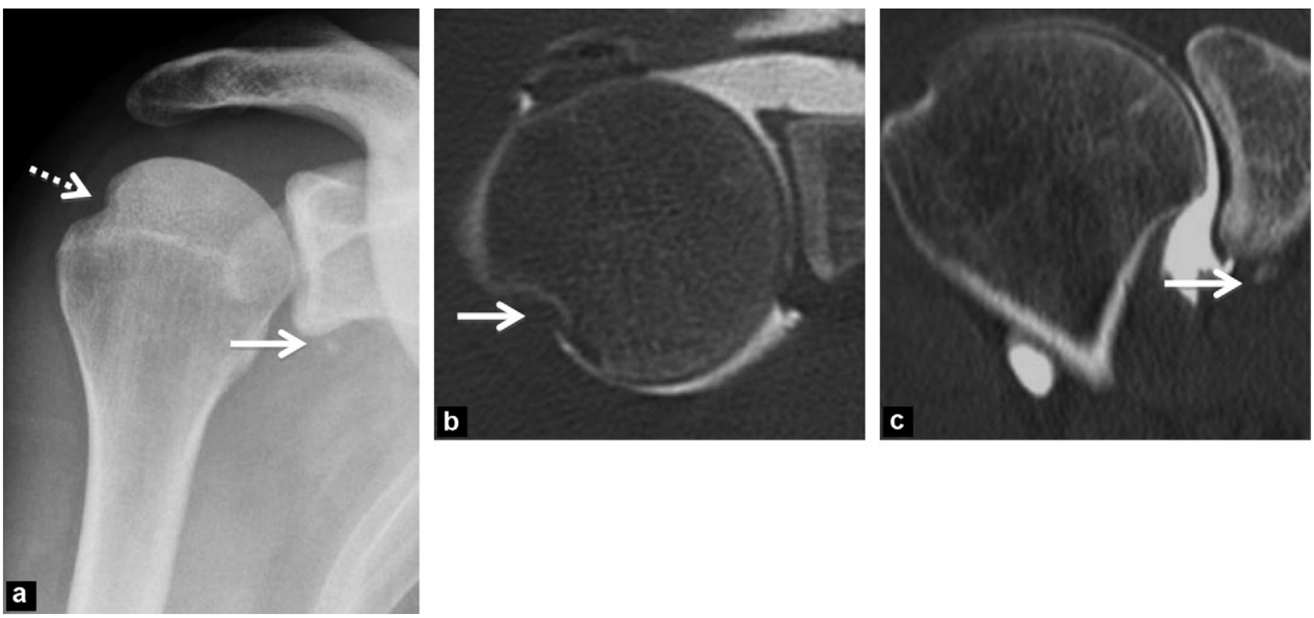

Figure 1. Anterior-internal dislocation of the shoulder. a: standard X-ray (front internal rotation): Malgaigne notch (dotted arrow) and bone tear at the lower edge of the glenoid (full arrow); b and c: the CT arthrogram (axial [b] and coronal reformats [c]) confirms the lesions.

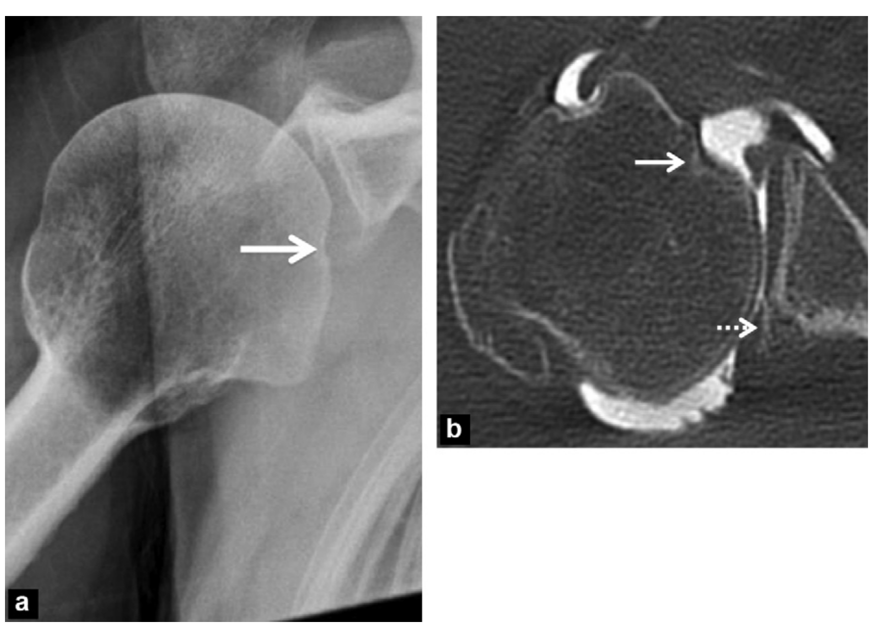

Figure 2. Posterior dislocation of the shoulder. a: the X-ray (Bloom-Obata angle) shows the Mc Laughlin notch (arrow); b: the CT arthrogram also shows a reverse Bankart lesion (dotted arrow).

Elbow

Post-traumatic intra-articular effusion is sometimes the only anomaly visible in an elbow fracture. It is easy to identify and harmful to disregard. These occult fractures often involve the radial head in the adult — sometimes the coronoid process or an epicondyle —, and the lower end of the humerus in child. Three fat pads should be searched for during the interpretation of an X-ray of the elbow (Fig. 3): anterior pad, posterior pad and line of the pronator teres. Their displacement attests to joint effusion. The visualisation of the posterior fat pad is inconstant due to bone superposition. The discovery of a post-traumatic effusion of the right shoulder, without manifest bone lesion, requires a dedicated CT examination.

Wrist

Wrist X-rays are sometimes difficult to interpret. Certain signs may help the radiologist although the CT should be used fairly easily in case of doubt. At least four views should be obtained: front, profile and two obliques, most often in pronation (scaphoid view) and supination.

With the front view, the fat border of the scaphoid is visible on the lateral side of this bone. Its displacement or disappearance indicates a fracture (Fig. 4) although this sign is not very sensitive and is not specific since De Quervain's tenosynovitis may have the same appearance. The outlines of the scaphoid, the lunatum and triquetrum should be checked in the search for a bone avulsion revealing a lesion of an intrinsic ligament (scapholunar and lunotriquetral). The ring at the level of the hamulus of the hamatum should be searched for as its absence indicates a fracture or a lack of fusion. The lateral view is used to search for a bone fragment at the dorsal edge of the triquetrum, corresponding to the avulsion of an extrinsic dorsal ligament (Fig. 4). The fat border of the pronator quadratus should be searched for on the anterior side of the distal radius (Fig. 5).

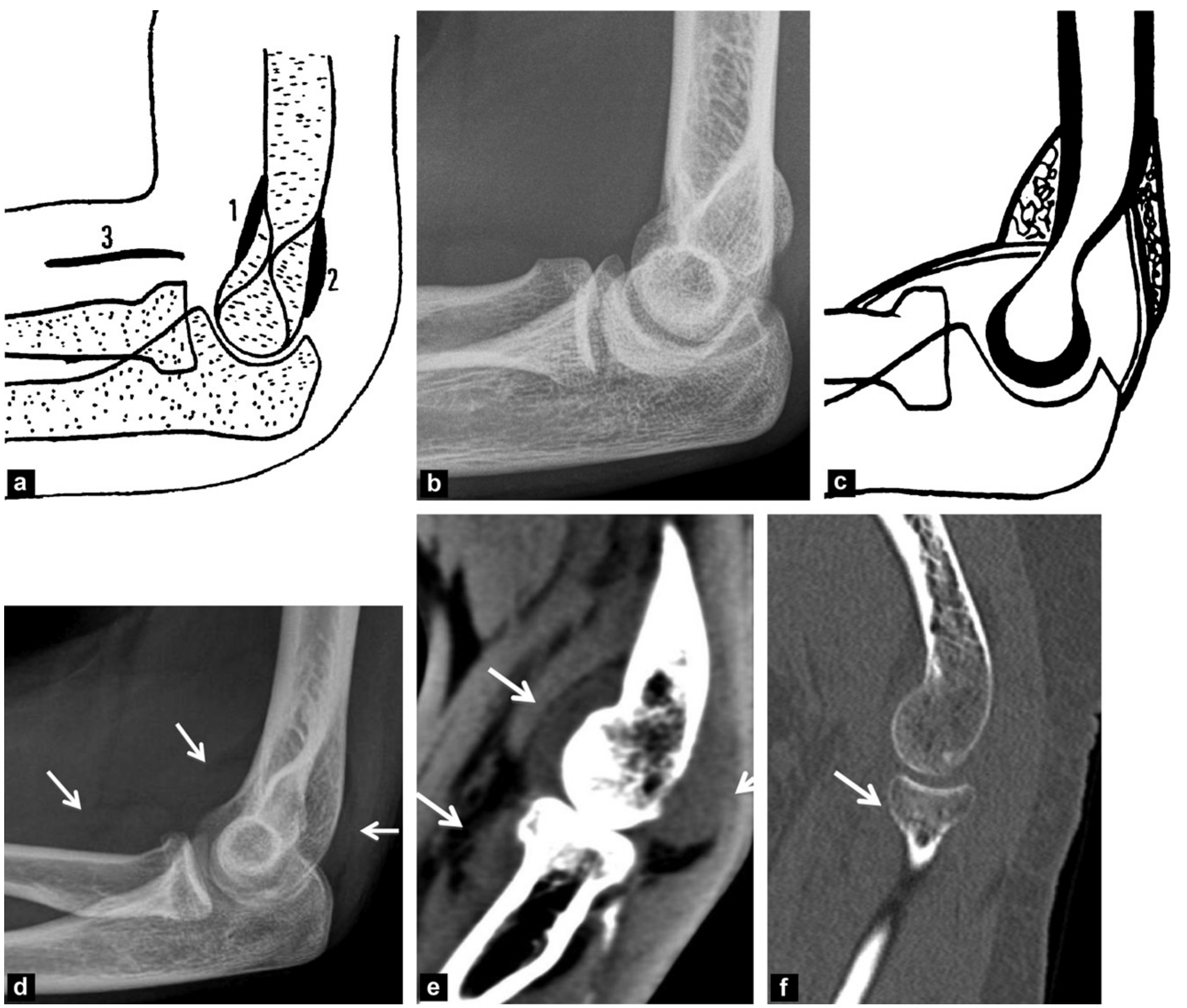

Figure 3. Intra-articular effusion of the elbow. a: normal elbow Three fat pads should be searched for (1: anterior; 2: posterior; 3: pronatror teres). They are not visible or slight in the normal state; b: correspondent X-ray (profile); c: effusion: the fat pads are displaced; d: traumatic elbow, the effusion is fully visible; e and f: CT (sagittal reformat) confirms the effusion and the cause is found, here a non-shifted, subtle fracture of the radial head.

Figure 4. Wrist. Fracture of the scaphoid (a, b), extrinsic ligament avulsion on the dorsal side of the triquetrum (c, d). a: displacement of the fat border in the standard X-ray (front); b: the fracture is fully visible on CT (coronal reformat); c: bone fragment of the dorsal side of the wrist in the profile X-ray; d: CT arthrogram, sagittal reformat: fracture-avulsion of the dorsal side of the triquetrum.

Hand

The main difficulty is to avoid underestimating the lesions when faced with bone ripping that may seem to be negligible, in particular at the thumb. Bennett's lesion is an example of this [1]. The standard X-ray shows a bone fragment at the base of the first metacarpal (Fig. 6). This lesion is actually an authentic fracture-dislocation of the trapeziometacarpal joint. The medial fragment remains attached to the trapezoid while the rest of the metacarpal is sub-dislocated under the action of the abductor pollicis longus. The treatment is surgical. Other lesions should attract attention, in particular the presence of bone fragments at the radial or ulnar edge of the finger joints that are related to the tearing of a collateral ligament.

Knee

One should immediately search for intra-articular effusion at the supra-patellar recess. Its presence in a traumatic context indicates hemarthrosis (Fig. 7) especially if it is very dense. The presence at the early stage should call to mind ligament lesions, in particular of the cruciate ligaments (Boxed text 1). The presence of a fat level in the liquid effusion (lipohemarthrosis) is pathognomonic of the passage of fat from the bone marrow to the joint, and therefore of a joint fracture. Detection at this level requires a horizontal ray. CT is indicated if the lesion is not visible in the X-rays (Fig. 8). A bone fracture or avulsion should be carefully searched for in certain strategic areas [2]:

Figure 5. Standard side X-ray: displacement of the fat border of the pronator quadratus in contact with a fracture of the radius.

Figure 6. Bennett's lesion. A bone fragment seems torn from the thumb column. In fact, this fragment remains attached to the trapezio-metacarpal joint and the thumb column is dislocated.

Boxed text 1 Lesions associated with a rupture of the ACL.

- Segond fracture and fracture-impaction of the lateral condyle and the lateral tibial plateau, almost pathognomonic.
- Constant hemarthrosis in acute phase.
- A fracture of the apex of the fibula may be associated with injury of the lateral stabilizers.

Figure 7. Hemarthrosis. Standard X-ray (side): intra-articular effusion (arrows) visible at the supra-patellar recess.

- Segond fracture (Fig. 9) consists of an avulsion of the lateral edge of the lateral tibial plateau at the level of the capsular insertion. It accompanies traumas in medial rotation with varus. It is almost pathognomonic of a rupture of the anterior cruciate ligament (ACL). Meniscal lesions may also be associated. A mirror-image Segond lesion may be noted in ruptures of the posterior cruciate ligament [3];
- the fracture-impaction of the lateral condyle and the lateral tibial plateau (Fig. 10) attests to the anterior translation of the tibia during rupture of the ACL. It is visible on the side X-ray and should be distinguished from the physiological notch of the lateral femoral condyle, which is under 2 mm;
- the fracture of the apex of the fibula or ''arcuate sign'', (Fig. 11) [4] attests to an impairment of the posterior-lateral stabilisers (posteriolateral corner). A rupture of the central pivot is often associated. The exact topography varies according to the bundle involved;
- when faced with a bone fragment in the intercondylar notch, avulsion of the insertion of the ACL (Fig. 12) [5] or the PCL (Fig. 13) [6] is suspected, at the anterior or posterior area of the intercondylar eminence, respectively. This lesion is all the more common when the patient is young. It is often found in the adolescent;
- finally, a free osteochondral fragment is searched for as it may attest to an episode of patellar dislocation (Fig. 14).

Ankle

The main difficulties are the detection of fractures of the dome of the talus [7] and the interpretation of bone fragments near the malleoli, in particular the lateral malleolus. Hemarthrosis is looked for in the side view (Fig. 15). As in the elbow, its presence requires a CT evaluation as soon as possible, in the absence of causal bone lesion. At the level of the lateral malleolus, it is advisable to differentiate bone

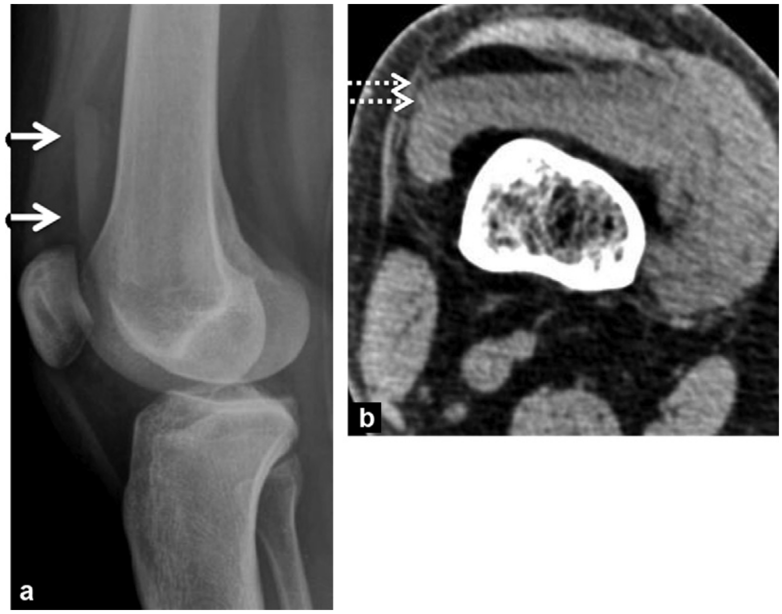

Figure 8. Lipohemarthrosis. a: lateral radiograph demonstrates a fat-fluid level in the effusion, attesting to a supernatant fat level (full arrows); b: CT (axial reformat) shows two levels, defining three strata, surface fat, hematic sediment in depth (dotted arrows).

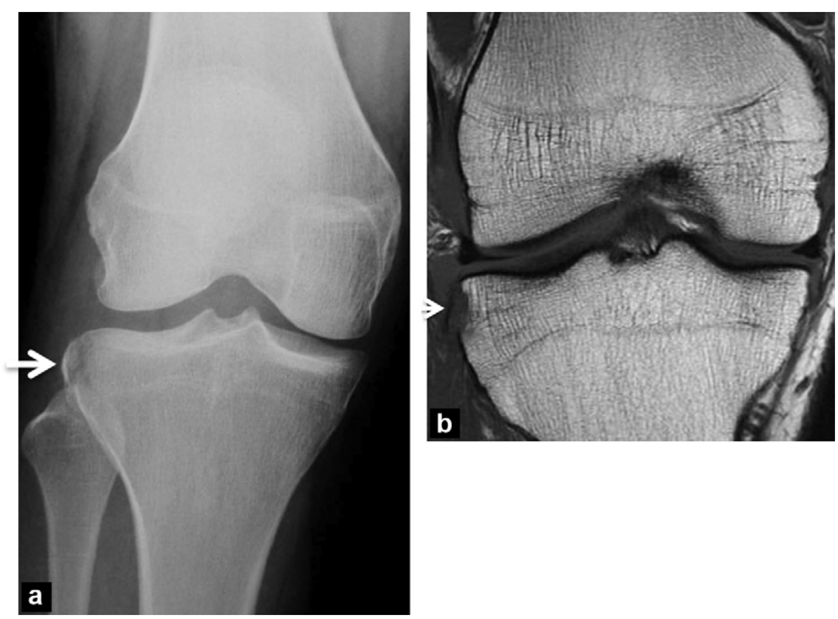

Figure 9. Segond fracture, associated with a rupture of the anterior cruciate ligament (ACL) (not shown). a: front X-ray: bone fragment at the lateral edge of the lateral tibial plateau (arrow); b: MRI (coronal T1 weighted).

tear following an avulsion of the insertion of a head of the lateral collateral ligament to the tear of the peroneal retinaculum (Fig. 16). In the latter case, the bone fragment is located at the upper part of the malleolus.

Foot

Traumas of the Chopart articular space (middle tarsal) and Lisfranc articular space (tarsometatarsal) are difficult radiology diagnoses. They require mastery of the anatomy and a good knowledge of physiopathology. In a traumatic context, the exploration consists of front and side X-rays and a foot progression (3/4). The Chopart joint associates the talocalcaneonavicular joint and the calcaneocuboid joint, stabilised by several ligaments. The avulsion of the dorsal talonavicular ligament may be easily diagnosed with the X-rays, associated with thickening of the soft tissue (Fig. 17). The oblique view may reveal a tear in the rostrum of the calcaneum at the level of the insertion of the bifurcate ligament or the base of M5 near the insertion of the peroneus brevis. The Lisfranc space unites the anterior tarsus and the metatarsals. It is reinforced by a powerful ligament, the Lisfranc ligament, extending from the medial cuneiform

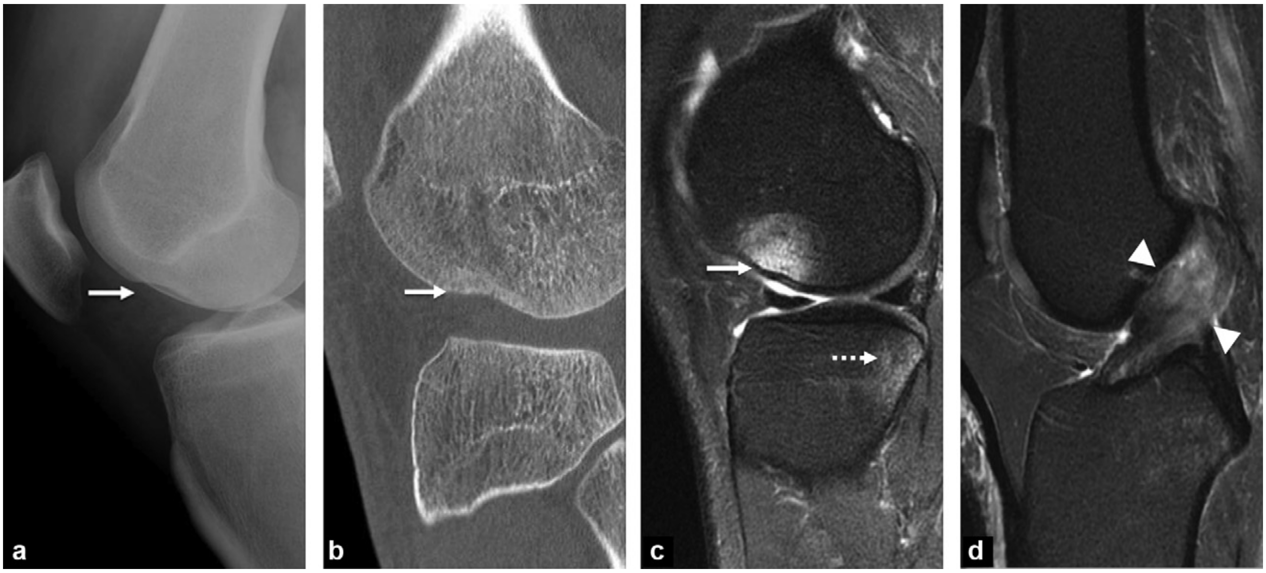

Figure 10. Fracture-impaction of the lateral condyle and the lateral tibial plateau. The anterior translation of the tibia at the time of the trauma induces an impaction of the anterior part of the lateral condyle of the femur on the posterior edge of the lateral tibial plateau. The anterior cruciate ligament (ACL), main stop to this anterior translation, is thereby broken. a: standard X-ray (side): notch of the lateral condyle; b: CT (sagittal). The impaction is clearly visible; c and d: sagittal fat-suppressed proton density MR image signal. Impaction of the femoral condyle (full arrow) and tibial plateau (dotted arrow). Concomitant rupture of the ACL (tip of arrows).

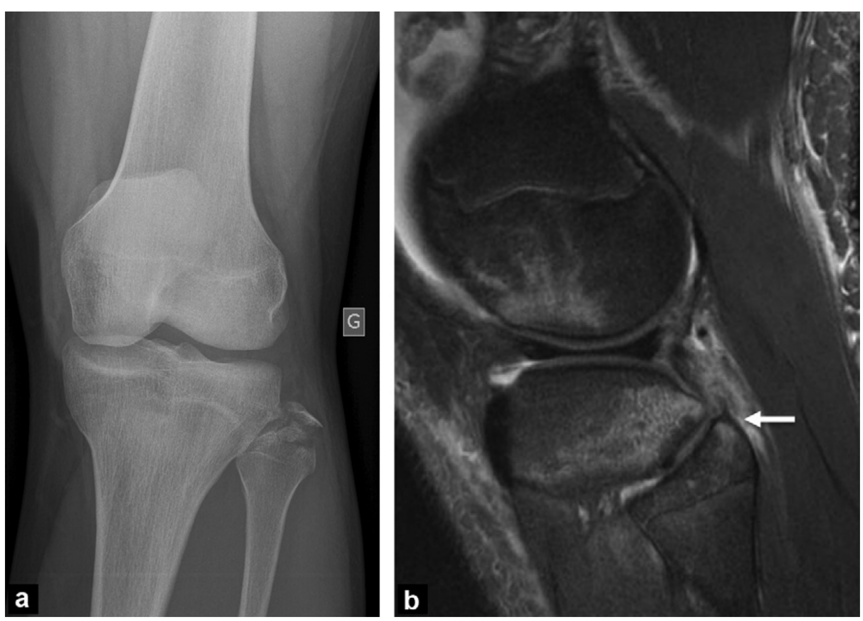

Figure 11. Arcuate sign. a: standard X-ray (front): fracture of the apex of the fibula; b: sagittal fat-suppressed PD MR image showing damage to the posterior-lateral stabilisers: hypersignal of the apex of the fibula at the level of insertion of the arcuate ligament and the collateral lateral ligament.

Figure 12. Avulsion of the ACL. a: standard X-ray (side): intra-articular bone fragment; b: CT (coronal):: avulsion of the anterior intercondylar area, site of the insertion of the ACL.

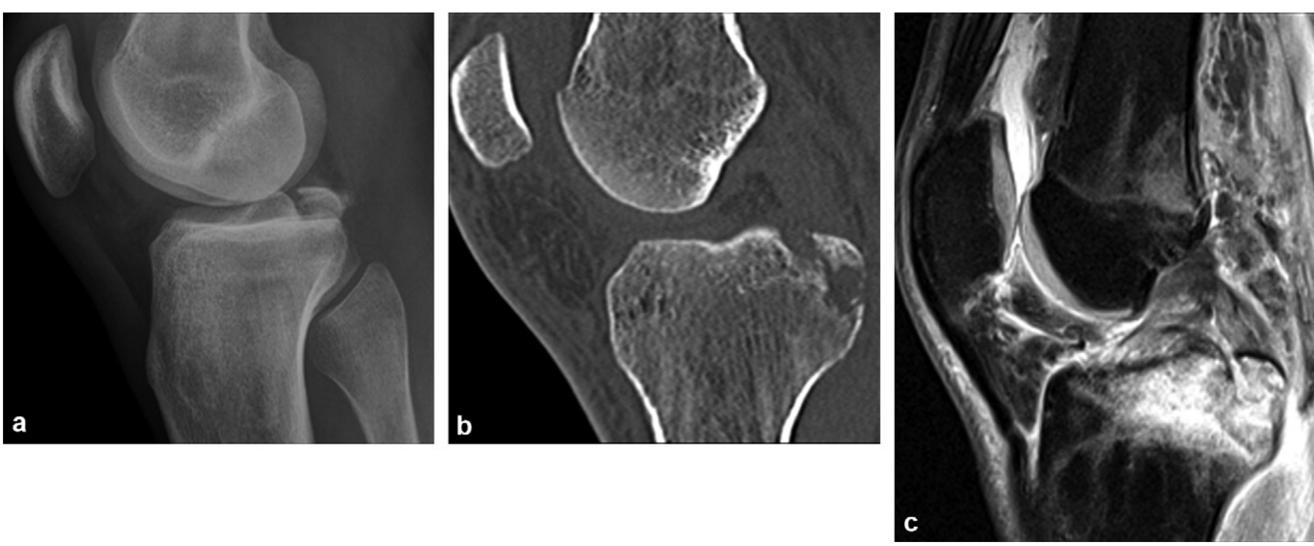

Figure 13. Avulsion of the PCL at its insertion on the posterior intercondylar area. a: standard X-ray; b: sagittal CT; c: fat-suppressed T2 weighted MR.

Figure 14. Patellar dislocation. a: standard X-ray: intra-articular bone fragment, of undetermined origin; b: CT (sagittal reormat); c: sagittal DP fat-suppressed MRI: confirmation of the intra-articular nature of this fragment; d: the MRI helps to confirm the lesional mechanism by demonstrating the signal anomalies of the medial edge of the patella and the lateral condyle of the femur (tip of arrow), attesting to the episode of lateral dislocation of the patella.

Figure 15. Hemarthrosis revealing a fracture of the dome of the talus. a: standard X-ray: normal ankle; b: standard X-ray: hemarthrosis: liquid filling the anterior recess; c: CT (sagittal reformat): confirmation of the hemarthosis; d: CT (coronal reformat): osteochondral lesion of the dome of the talus.

to the base of the second metatarsal. Sprains of the tarsometatarsal joint most often occur during accidents in the street, falls from a high place or athletic traumas [8]. An estimate of about 20% of all lesions are ignored in the initial standard X-rays. Certain signs should be known in order to call to mind the lesion and complete the exploration by CT. It should be noted that the interpretation of this joint is best made with a load. Three points are especially important (Fig. 18):

- the perfect alignment of the bone pieces, in particular the medial edges of M1 and the medial cuneiform and M2 and the intermediate cuneiform on the front X-ray. In the ¾ X-ray, the alignment of the cuboid is checked with the base of M4;
- the presence of a sentinel avulsion of the Lisfranc ligament, in the form of a bone fragment between the medial cuneiform and the base of the second metatarsal;
- the existence of a fracture of the base of the metatarsals, in particular of the second metatarsal, physiologically ''set'' between the medial and lateral cuneiforms.

Spine

Standard X-rays remain, outside of the polytraumatism, the first intention examination in the exploration of spinal traumas. Reputed to be difficult and not very sensitive, they are actually rich in information for those that look for it. It is possible to distinguish anomalies of the soft tissue, vertebral body avulsions, fractures of the spinous process and transverse process [9]. We finally discuss the problem of ''compression of the spinal column''.

Study of the soft tissue is part of the interpretation of any X-ray. It obeys strict rules at the level of the cervical spine (Fig. 19). They are studied on the side view at the cervical level and front view in the thoracolumbar level (Fig. 20). Any anomaly should lead to a CT or even an MRI in the search for a lesion of the anterior common vertebral ligament.

A bone avulsion should be known in the cervical spine. It consists of the ''tear-drop'' (Fig. 21), spinal transsection by hyperflexion, thereby highly unstable. Therefore, the only manifestation on the standard X-ray is sometimes the detachment of an anterior-inferior bone fragment that remains united with the underlying disk. This anomaly should not be ignored but should lead to the immobilisation of the patient and a CT to confirm the lesion by demonstrating the classic triad: one tear, two fracture lines: one coronal that separates the antero-inferior fragment, the second sagittal, three fragments. With the discovery of a fracture of the spinal process, the direction of the streak should be examined. If vertical at the cervical spinal level (Fig. 22), it most often consists of a fracture in

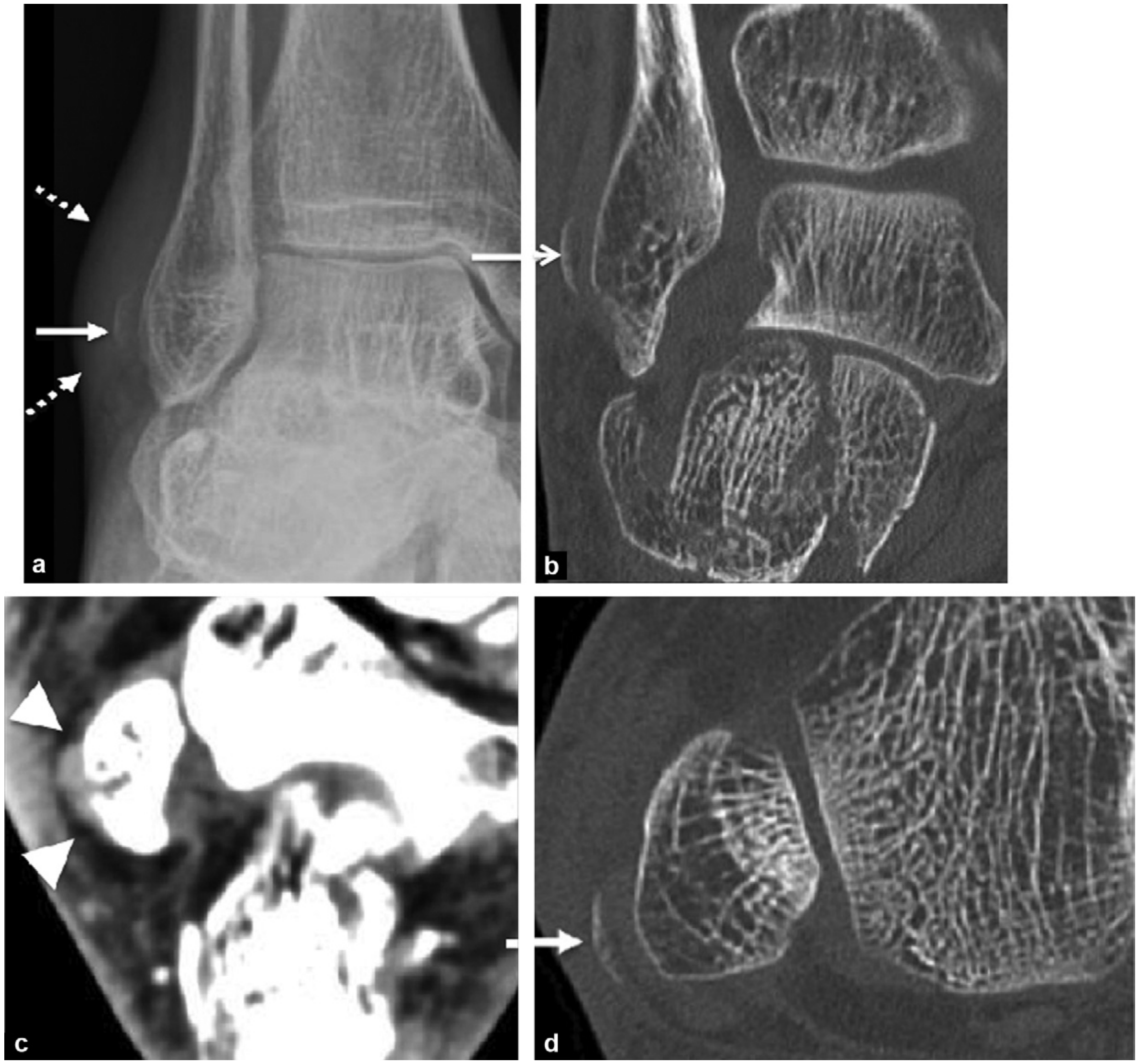

Figure 16. Dislocation of the fibular tendons. a: X-ray: tumefaction of the lateral peri-malleolar soft tissue (dotted arrow) associated with a bone avulsion (arrow); b, c, d: by scan in coronal section (b) and axial CT reformat (c and d). This avulsion corresponds to a tear of the fibular retinaculum (tip of arrow). In addition, there is a fracture of the calcaneus.

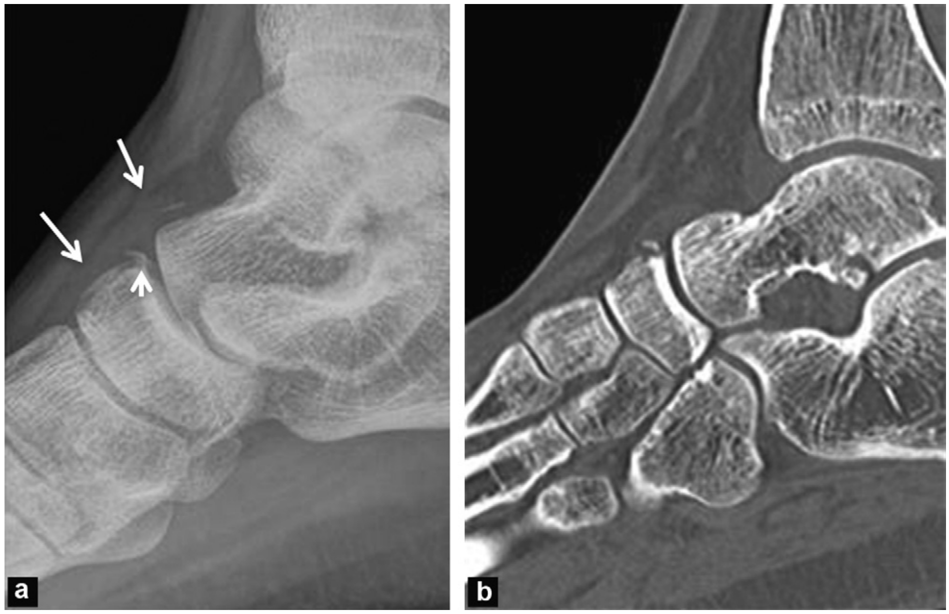

Figure 17. Chopart sprain. Thickening of the soft tissue (long arrows) and avulsion of the navicular insertion of the dorsal talonavicular ligament (short arrow). a: X-ray; b: CT (sagittal reformat).

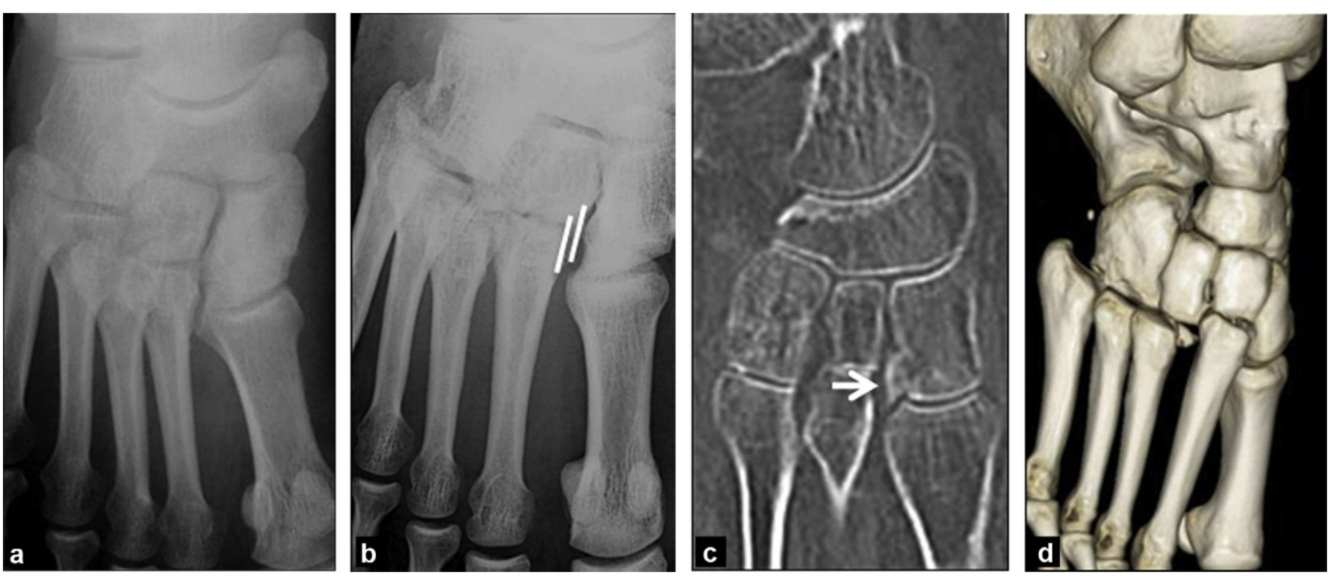

Figure 18. Lisfranc sprain. a: standard X-ray: normal alignment normal of the bone pieces; b: standard X-ray: Lisfranc sprain: loss of normal relationship between the intermediate cuneiform and the base of M2; c: CT (axial) shows the avulsion of the Lisfranc ligament; d: the volume rendering technique (VRT) mode allows for a better study of the anatomical relationships in the major shifts.

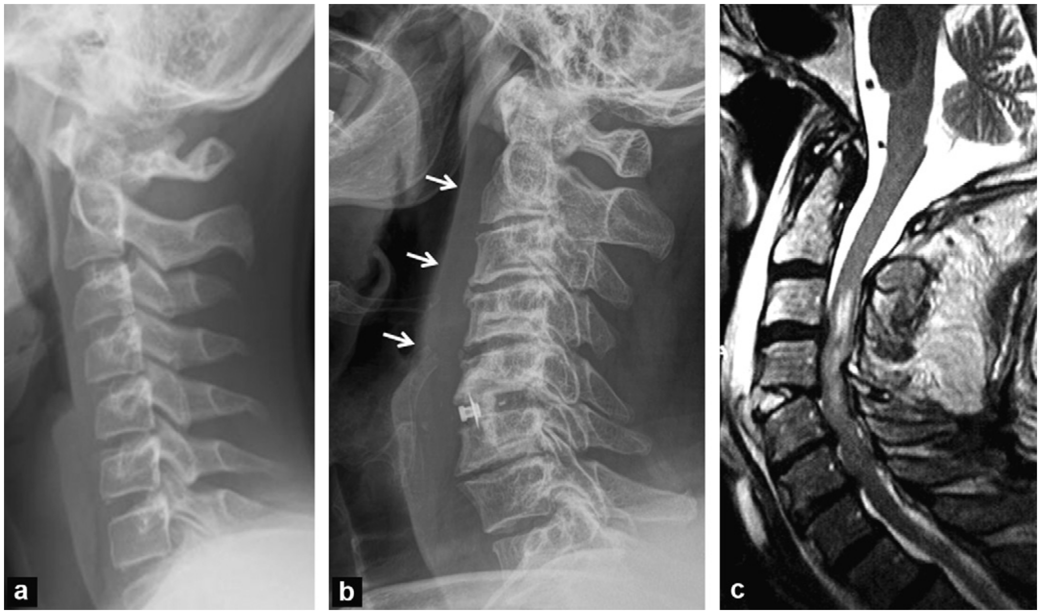

Figure 19. Study of the pre-vertebral soft tissues. a: normal X-ray. The soft tissues are concave towards the front above and at the level of C2 and the thickness is inferior that of the base of the odontoid process; thickness less than 7 mm from the anterior-inferior corner of C2 to C4; less than 21 mm below that of the adult; b: post-traumatic X-ray: pathological thickening of the soft tissue without obvious bone lesion; c: sagittal T2 weighted MRI (in another patient) shows the interruption of the anterior common vertebral ligament, a discal fracture with hypersignal and an intra-medullar hypersignal. Also posterior impairment with hypersignal of the ligamentum flavum and of the soft tissues behind the spine.

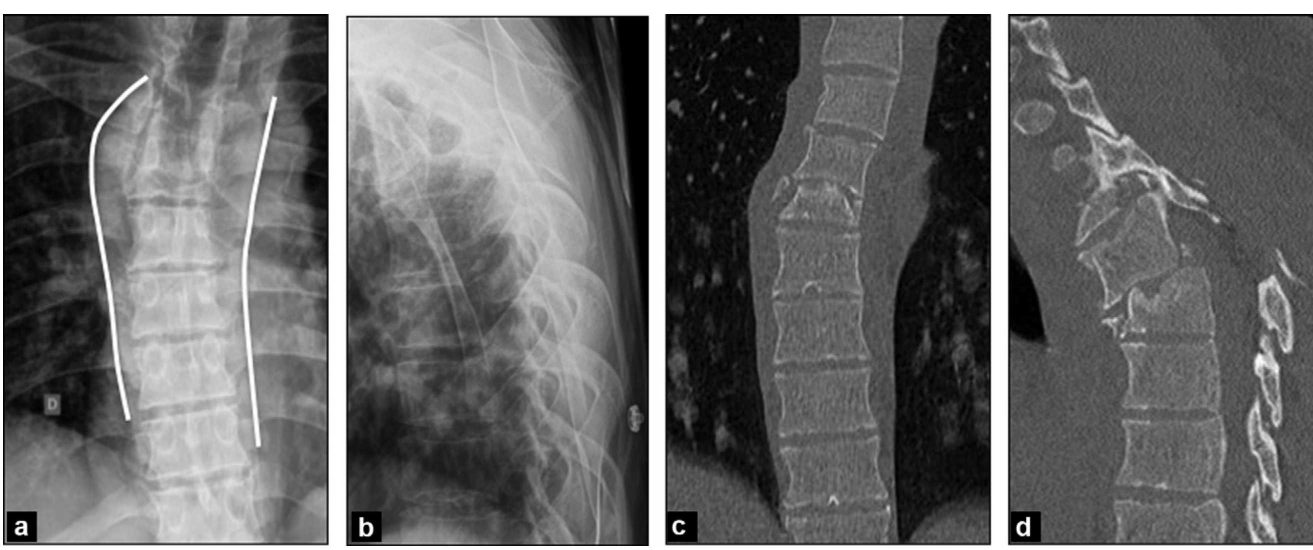

Figure 20. Trauma of the thoracic spine. a, b: the X-rays show a para-vertebral soft-tissues swelling; c, d: CT (coronal and sagittal) show a fracture-dislocation T4-T5.

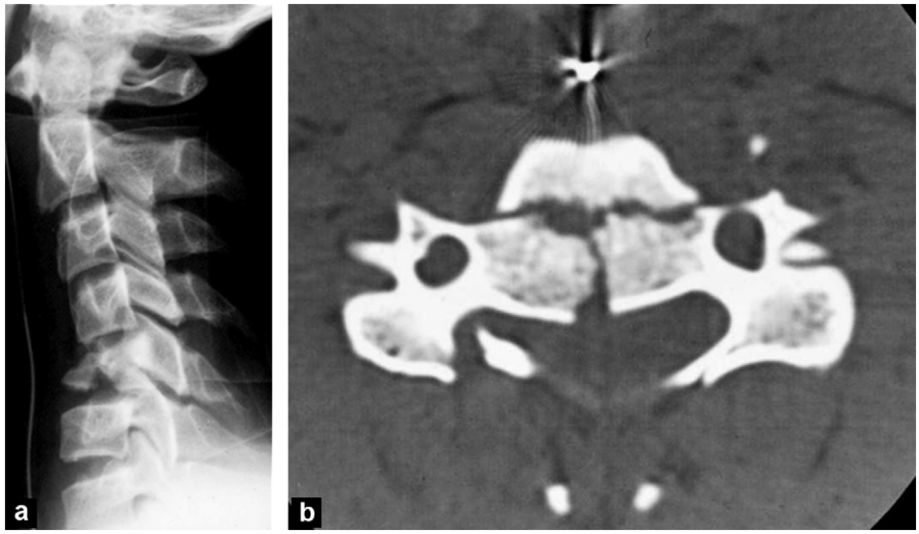

Figure 21. Tear drop fracture. a: lateral radiograph: avulsion of the anterior-inferior corner of C5; b: CT(axial reformat) confirms the tear drop by showing the components, sagittal and coronal, two fracture lines with three fragments.

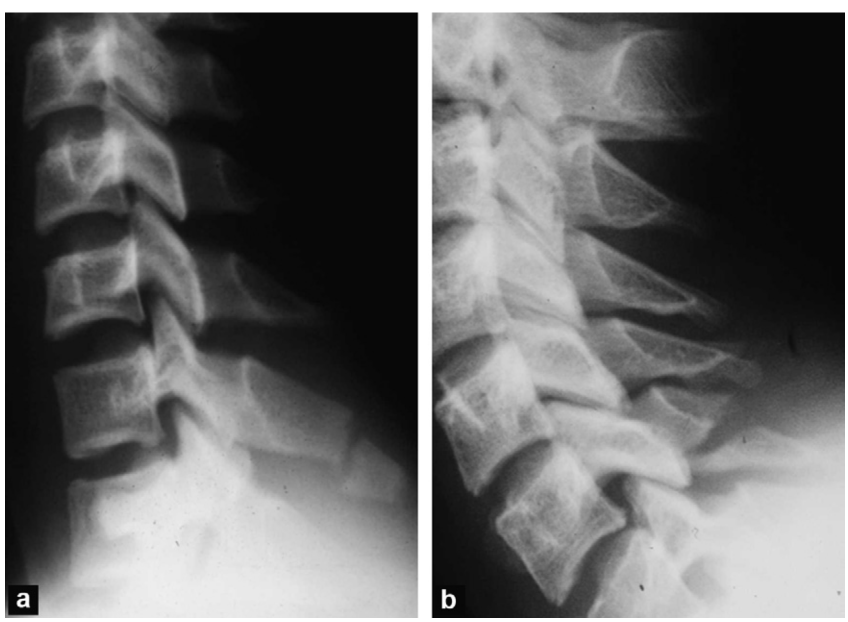

Figure 22. Fracture of the spinal process. Orientation of the fracture line. a: vertical and isolated line; b: horizontal line with risk of cervical instability.

Figure 23. Chance fracture of the thoraco-lombar junction. Mechanism in hyperflexion inducing a spinal transsection. Posterior opening of the spinous process T12 associated with a collapse of the upper plateau of L1.

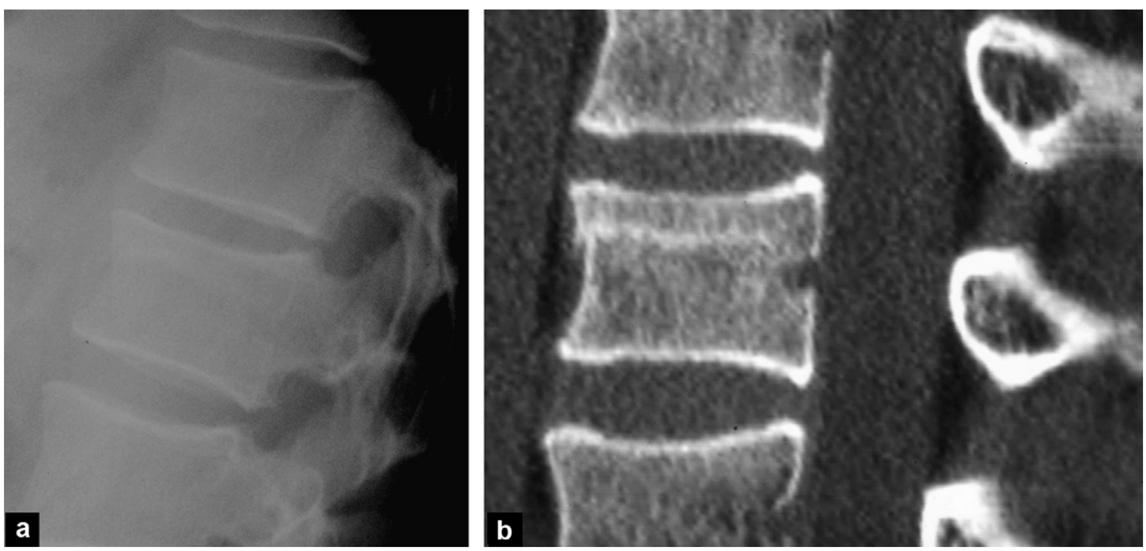

Figure 24. Compression fracture with endplate impaction. a: standard X-ray: compression of the upper plateau, the height of the posterior wall is respected. No anomaly of the posterior arch; b: CT (sagittal reformat): confirmation of a A1 type compression fracture.

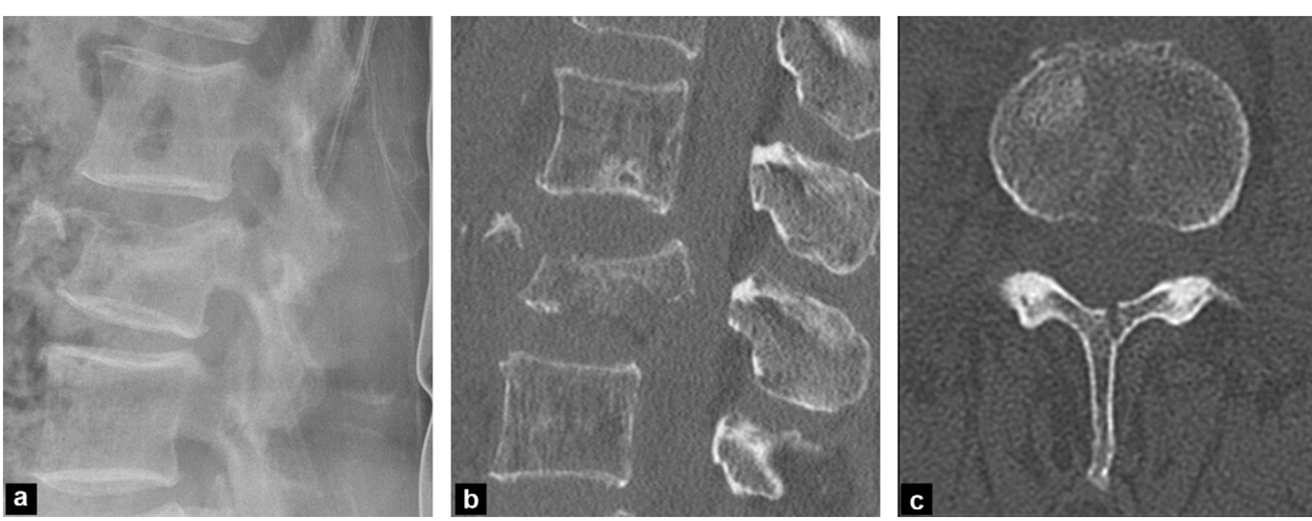

Figure 25. Burst fracture. a: standard X-ray: compression of the upper plateau. Loss of height of the posterior wall with respect to the adjacent levels, without lesion of the posterior arch; b: CT (sagittal reformat); confirmation of damage to the posterior wall; c: vertical spinolaminar split (A3 fracture).

hyperextension, isolated and benign, outside of the violent traumas with spinal transsection. However, a horizontal orientation attests to a mechanism in hyperflexion with ''opening of the vertebra'', at the origin of a possible impairment of the mobile spinal segment, best assessed by MRI. In the lumbar spine, a horizontal orientation of a fracture of a spinal process requires a CT to search for a Chance fracture (Fig. 23). This lesion is associated with road accidents, in particular in passengers wearing seat belts, with hyperflexion around the seat belt. The lesion is then located at the thoracolumbar junction. It is often associated with visceral lesion, requiring a thoraco-abdomino-pelvic CT with injection of contrast product. Fractures of the transverse process are relatively frequent in the lumbar spine. They are rarely in the forefront. There are very often associated with visceral lesions and/or lesions of the lumbosacral junction. The term ''compression of the spinal column'' is to be used with care. The loss of height in a vertebral body may result from several causes, from a simple endplate impaction without impairment of the posterior wall (Fig. 24) — Magerl type A1 [10] — to a Chance fracture (Fig. 23) — type B1— passing by a burst fracture (Fig. 25) — type A3. It is therefore necessary to check the integrity of the posterior wall (burst) and the neural arch (Chance) before concluding as to a simple ''compression''. A CT evaluation is indispensible in case of doubt.

Conclusion

The search for intra-articular effusion should be systematic during the interpretation of standard X-rays in a traumatic context. Bone avulsions should not be neglected. They often attest to an underlying capsulo-ligamentary lesion. The discovery of a seemingly banal fracture in standard X-rays does not exhaust the subject, as it may be associated with other more serious lesions.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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